Managing Fall Armyworm

A guide to low cost pest management approaches

Acknowledgment

We would like to thank the Norwegian Agency for Development Cooperation (NORAD) who funded this work.

Introduction

Fall armyworm (FAW), scientific name *Spodoptera frugiperda* Smith, is an invasive pest that first arrived in sub-Saharan Africa in 2016.

It is a pest of maize and other cereals, although it can eat many plants, and when it first arrived, fearful of the damage it might wreak, regional governments released millions of USD to purchase and distribute pesticides to farmers. Unfortunately, many of these chemicals were not effective. In addition, there are serious risks to human health and environment from the misuse of chemical pesticides.

Since 2016, we have learnt a lot about the biology of FAW in Africa[1,2]. We understand that the impact of FAW is not as severe as originally feared. In most places most of the time, it causes little damage. Many native natural enemies attack FAW and help keep its population under control. Furthermore, there are many low-cost options farmers can use to reduce FAW populations and control outbreaks when they occur.

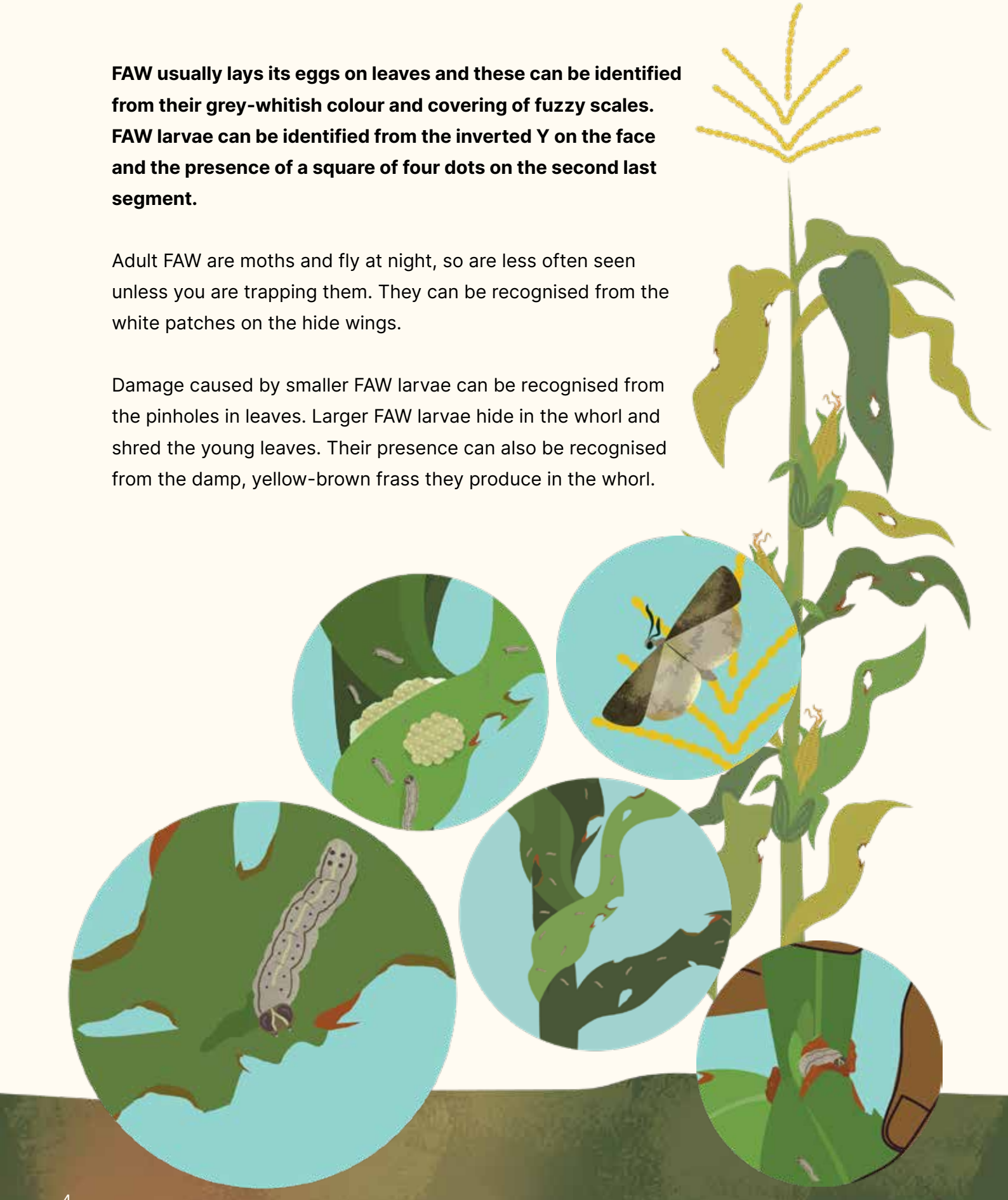
We urge farmers to adopt an Integrated Pest Management, or IPM, approach, which emphasizes PREVENTION and MONITORING. Pesticides may be used as a last resort, when monitoring has determined that pest populations have reached an 'action threshold'. However, the use of BIOLOGICALS is preferred, as these better protect natural enemies. It is also essential that when pesticides are used, farmers apply safety protocols and proper application techniques to ensure efficacy and minimise environmental damage and health risks.

How to recognise Fall Armyworm (FAW)

FAW usually lays its eggs on leaves and these can be identified from their grey-whitish colour and covering of fuzzy scales. FAW larvae can be identified from the inverted Y on the face and the presence of a square of four dots on the second last segment.

Adult FAW are moths and fly at night, so are less often seen unless you are trapping them. They can be recognised from the white patches on the hide wings.

Damage caused by smaller FAW larvae can be recognised from the pinholes in leaves. Larger FAW larvae hide in the whorl and shred the young leaves. Their presence can also be recognised from the damp, yellow-brown frass they produce in the whorl.



Natural enemies

Natural enemies are organisms living in farmers' fields that attack pests.

Many are insects, including parasitoids and predators, but they also include fungi, nematodes and others. Bats are very important natural enemies that feed on adult FAW and some birds also eat the larvae. It is important to protect natural enemies, as they are the farmers' best friends in the fight against FAW and other pests.

African Flycatcher Bird

Greenbul Bird

Insectivorous Bat

Hunting Spider

Earwigs

Predatory Beetles

Ant

Social Wasp

Parasitoids

Assassin Bug

Prevention

Avoid late planting

After the dry season, FAW populations are naturally very low[3]. Timely planting, after the first three good rains, will ensure the crop passes through the vulnerable stages before the FAW population has had a chance to build up.

If you plant late (i.e. 1-2 months after initial plantings), FAW can move from neighbouring fields on to the newly planted maize and will often cause a lot of damage.

Practice good soil management

Healthy plants are more resistant to pest attack and can recover from damage. In fact, maize can recover from severe damage with little loss of yield, if plants are healthy[4].

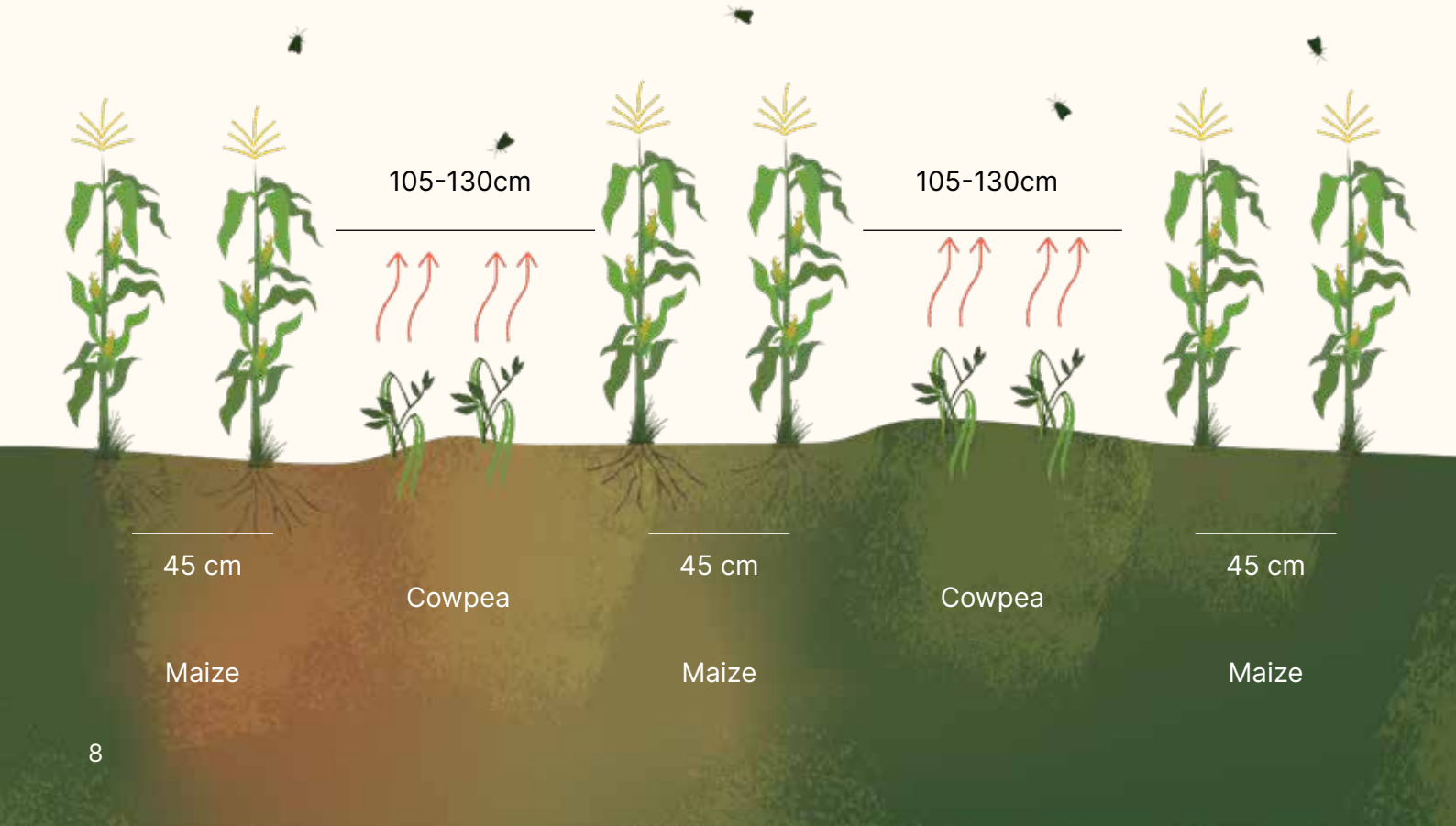
Best is to manage soils using natural fertilisers, such as animal manure or compost. Alternatively, use nitrogen fixing plants like fertiliser trees. These approaches not only provide the crop with sufficient nutrition, but also enhance the biological activity of the soil, which enables the maize to absorb nutrients efficiently. It is essential to promote soil carbon through practices such as minimum tillage and residue retention (or adding mulch), and through crop rotation. Organic matter improves soil structure, water holding capacity and encourages biological activity. The worst thing you can do is to burn your fields in the dry season, as this removes all the organic matter and exposes soils to erosion when the first rains arrive. An added advantage of using natural fertilisers is that it provides a good habitat for natural enemies.

If you are using chemical fertilisers or combining chemical fertilisers with natural soil management approaches, such as mulching, be sure to apply the correct dosage. It is better to manage a smaller area of maize properly than to under-fertilise a larger area. Weak plants do not recover from FAW attack well and yields are likely to be reduced. Many farmers report that their fields recover from FAW attack after Urea top dressing is added. This is expected because the Urea provides the nitrogen the maize needs during its growth spurt.

Intercropping with legumes

Intercropping maize with legumes, such as cowpea, ground nuts, beans, velvet beans and pigeonpea, or fertiliser trees like *Faidherbia*, *Tephrosia* or *Gliricidia*, reduces FAW infestation and damage[5,6]. The intercrop provides ground cover, thereby providing good habitat for natural enemies, and may also discourage FAW moths from laying eggs.

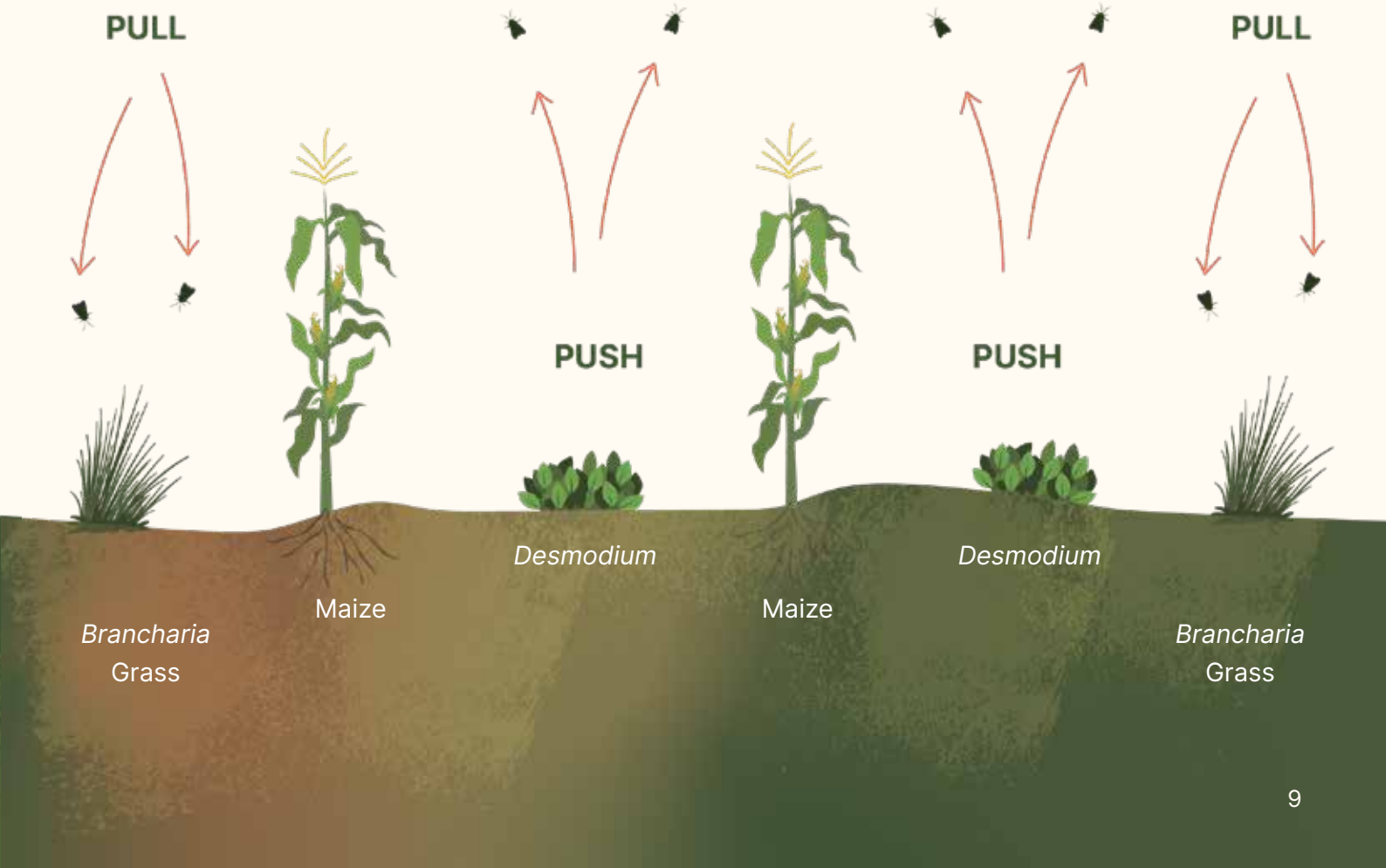
When intercropping with legume crops or cover-crops, it is best to plant two rows of maize about 45 cm apart followed by a gap of 105-130 cm (i.e. ally system). This provides more light for the intercrop leading to more robust growth. The intercrop is planted into the gap at the same time as the maize. However, if planting velvet bean, lablab or other cover-crops that have very strong growth, it is best to plant these one month later to avoid smothering the maize. For shrub-like intercrops and fertiliser trees, including pigeonpea, *Faidherbia*, *Tephrosia* and *Gliricidia*, usually 5-6 rows of maize are planted between alleys of the intercrop.



Push-Pull

Push-Pull' is where an intercrop (the 'push'), usually *Desmodium*, is combined with a 'pull' crop, such as *Bracharia* grass, that is planted around the edges of a field.

Push-Pull has been shown to be effective in reducing FAW infestation in dry environments in East Africa[7]. Its attraction to farmers depends on whether the *Desmodium* and *Bracharia* can be used for fodder, and also if there is a risk of *Striga* infestation, because *Desmodium* is effective for controlling *Striga*.



Trapping adult FAW moths

A simple trap can be made from a 2 litre soda bottle painted yellow. A pheromone lure is used to attract male moths and the traps is filled with water with a little detergent.

When the moths are attracted to the trap, they fall into the water and drown. Because the pheromones only attract the males, the trap does not prevent FAW infestation, but they disrupt the mating and reduce the population.

Biological control

There are different types of biological control. In classical biological control, a natural enemy of the pest from its area of origin is introduced to control the pest. In augmentative biological control a company breeds native natural enemies in a laboratory and then sells them to a farmer (or government) to release. For conservation biological control, farmers modify the environment around their fields to encourage natural enemies by providing habitat, alternative food sources, or nest sites.

Good practices for conservation biological control include protecting fragments of native forest, and planting or regenerating native trees and shrubs along field boundaries. Species that produce showy flowers are especially good, as parasitoids feed on the nectar. Critically important is to avoid using chemical pesticides, as these kill natural enemies. The most important predators include social wasps and ants, so be sure to protect their nests. If you find a bat roost, be sure to protect it too, as the bats feed on the adult moths.

FAW resistant / tolerant varieties

A number of FAW resistant and tolerant seed varieties are now available.

These show good yield responses to intense FAW attack. Hence, farmers may wish to use these in hotspot areas where FAW infestations are typically high. However, in other areas, where FAW infestations are not usually severe, farmers are likely to get better yields using their normal choice of variety.

Pesticide seed coatings

Certain systemic pesticides are available as seed coatings, and have been found to be effective against FAW (e.g. Fortenza™ Dua).

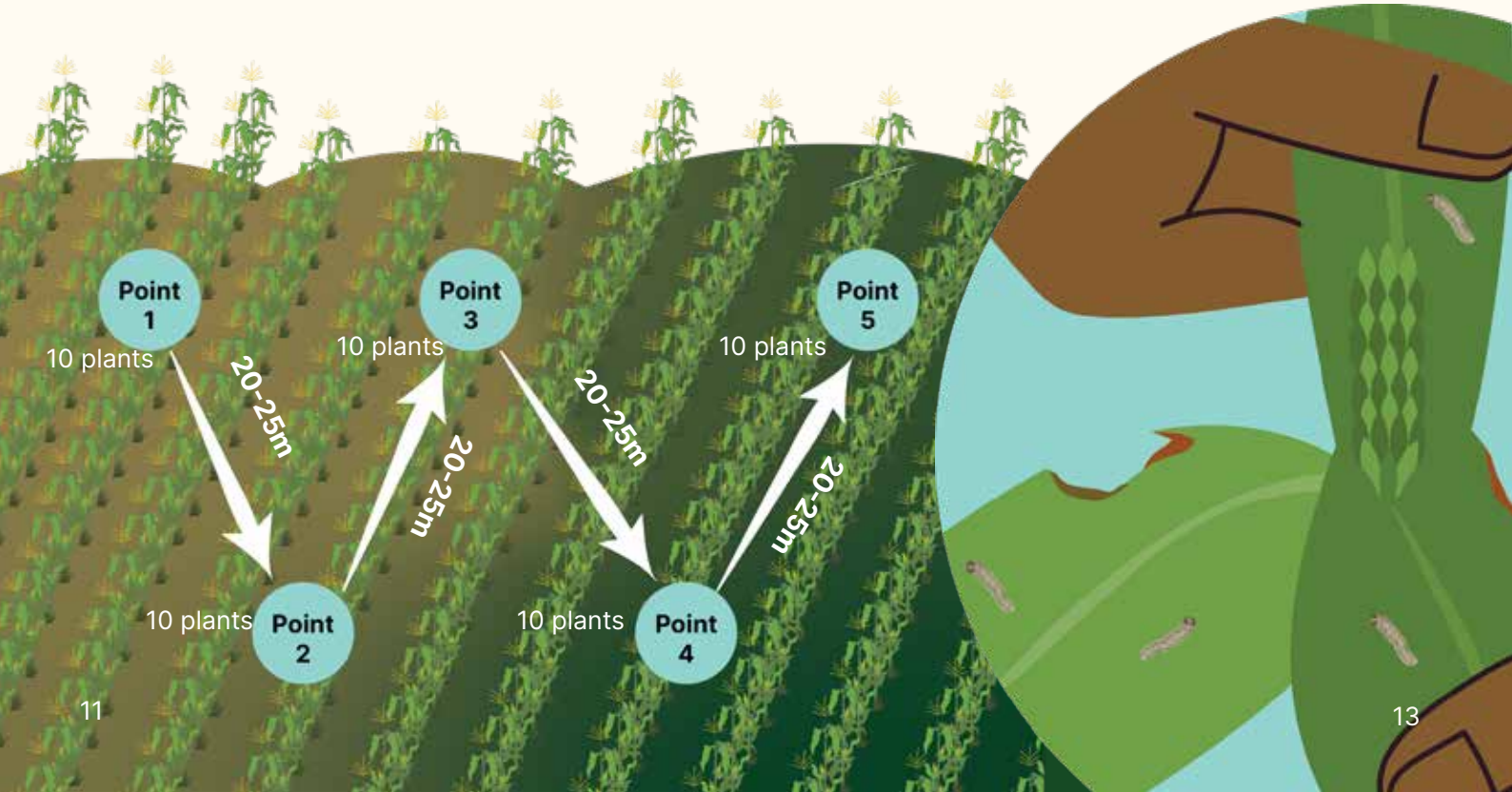
Farmers in hotspot areas, where FAW infestations are typically high, may wish to use this approach. However, these pesticides have severe impacts on natural enemies and soil organisms[8], and hence are not advised where FAW infestations are not expected to be severe. In addition, farmers must use the appropriate protective clothing. Handling of seeds coated in pesticides poses a high health risk through direct contact with the skin or via food eaten with contaminated hands.

Monitoring

The only reliable way to assess the severity of a FAW infestation is through scouting and assessing the damage to plants.

Pheromone traps indicate that FAW is in an area and hence provide some early warning, but are not a reliable indicator of the severity of an attack[3]. Infestation rate (i.e. the proportion of plants with FAW larvae) is also unreliable, because many of the younger larvae will be eaten before they do much damage[2]. The only reliable indicator is the amount of FAW induced damage to the crop, and especially the proportion of severely damaged plants.

Starting around two weeks after emergence, fields should be scouted every two weeks throughout the growing season. To scout a field, the farmer should survey 5 points by walking a W-shape or zigzag through the plot, with each leg of the W or zigzag being about 20-25 m. At each survey point, the farmer inspects the 10 closest plants (it is important that the farmer does not search for infested plants, as this will inflate the estimates of the severity of an infestation). For each of the ten plants, the farmer checks the top three leaves and whorl and assesses whether these have i) no damage, ii) light damage or iii) severe damage. If 10 or more are severely damaged out of the 50 plants inspected, the farmer should consider interventions to control the population (see below). If the number of severely damaged plants is between 2 and 9, or 10 or more plants are lightly damaged, the farmer should monitor the field weekly to determine if the infestation gets worse.



Interventions to control FAW populations

Cultural interventions

Picking or crushing

FAW eggs can be crushed between finger and thumb, while the larvae can be picked out of the whorl.

Rainfall forces FAW larvae to crawl out of the whorl to avoid drowning, so picking immediately after heavy rain is more efficient and avoids damaging the growing tip.

Sand and ash

A little fine river sand or a mixture of sand and ash can be poured into whorls that have FAW larvae.

The sand acts as an irritant that damages the skin and prevents the FAW larvae from feeding. Some farmers have used soil, but this is likely to be less effective than fine sand.

Fish soup

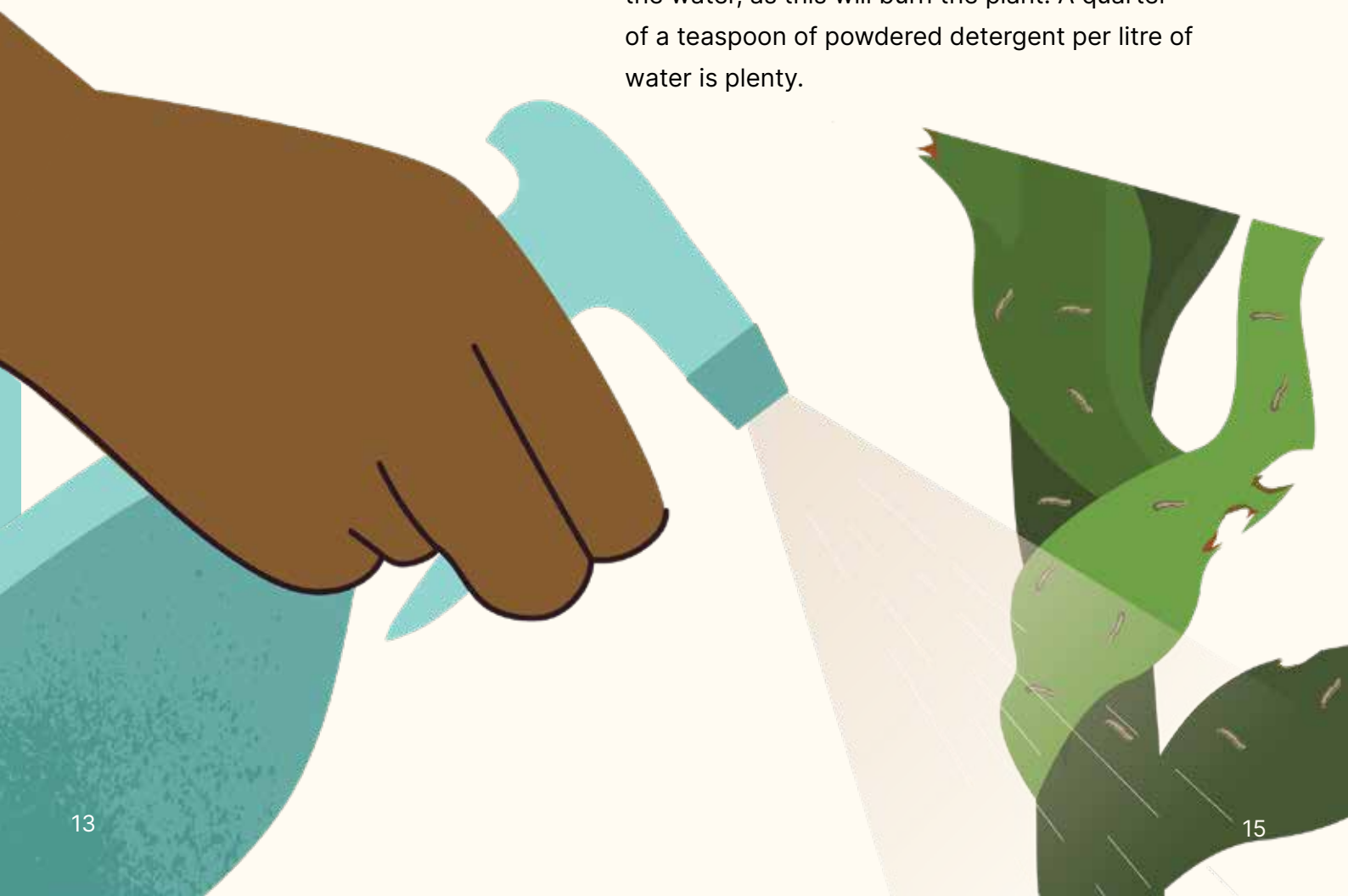
A thin stew of fish or a mixture of fish soup and sugar can be dribbled into the whorl and on to the leaves of plants with FAW larvae.

The fish attracts ants and other predators, which then attack the FAW larvae. The advantage of fish soup is that it also acts as a foliar fertilizer and improves plant growth.

Water and detergent

Spraying (or dribbling) water with a little detergent into the whorl of infested plants kills the FAW larvae by drowning.

It is important not to put too much detergent into the water, as this will burn the plant. A quarter of a teaspoon of powdered detergent per litre of water is plenty.



Biological pesticides

There are a number of biological pesticides that are effective against FAW. These include mating disruptors (e.g. Pherogen™), feeding inhibitors (e.g. Neem, *Azadirachta indica*), Nucleoployhedrovirus (NPV) (e.g. Fawligen™), entopathogenic fungi and nematodes.

Biologicals tend to be more expensive than chemical pesticides, but they are very effective and do not harm natural enemies so are to be preferred. It is important to understand that biological pesticides do not poison pests and so the FAW larvae often persist on the crop for a period of time (e.g. 7-14 days) after application of the pesticide. However, they are sickening and do little damage. Some biological pesticides require multiple applications to be effective. It is important to follow dosage instructions, application techniques and safety warnings for effective and safe use of biological pesticides.

Neem is a very effective biological pesticide against FAW[4]. While commercial formulations exist, it is also possible to make your own. Harvest 5 kg of Neem leaves, remove the midrib, and crush using a pestle and mortar. Add the crushed leaves to 5 litres of water and leave to soak over-night. Filter the liquid using a cloth and add a teaspoon of detergent to the water before applying the liquid to the crop using a knapsack sprayer. The pestle and mortar should be scrubbed out and washed thoroughly before it is used to prepare food again (or preferably, reserve one only for preparing Neem). Neem is a feeding inhibitor, which makes the FAW larvae feel sick and prevents them feeding, so that they slowly starve and die.

Chemical pesticides

There are a number of chemical pesticides that are known to be effective against FAW (Table 1)[8]. These are mostly newer formulations and hence often more expensive. However, many older formulations are not effective because of the development of pest resistance.

Table 1: *Chemical pesticides know to show high efficacy against FAW. The table is organised according to the risk to human health and the environment.*

High risk pesticides requiring maximum PPE with engineering and behavioural mitigation	Acephate, gamma-cyhalothrin, lambda-cyhalothrin, cypermethrin, deltamethrin, diflubenzuron, emamectin benzoate, fenvalerate
High risk pesticides to human health and the environment requiring double-layer PPE and either eye or respirator protection or both	Bifenthrin, alpha-cypermethrin, beta-cypermethrin, indoxacarb
Lower risk pesticides to human health requiring single-layer PPE, but high environmental risk	Lufenuron, novaluron, spinetoram, spinosad, teflubenzuron, triflumuron
Lower risk pesticides to human health and environment requiring single-layer PPE	Bacillus thuringiensis serovar aizawai, chlorantraniliprole, flubendiamide, methoxyfenozide, pyrethrum

Source: *Jepson et al 2020. Lancet Planetary Health 4: e56-e63*

It is important that farmers appreciate that chemical pesticides often impact natural enemies more than they impact the pest. Hence, they should only be used as a last resort. It is essential that proper dosages, application techniques and safety precautions are applied.

Trap crops

Protecting cobs against FAW damage

If a crop is moderately to heavily infested during the vegetative phase, FAW can sometimes cause appreciable damage to the cobs.

To avoid this, farmers can use freshly planted maize as a trap crop. Just prior to the tasselling stage, 2-4 rows of maize are planted around the plot (or along paths within the plot). As the young maize emerges, the FAW will move on to the young plants thereby protecting the cobs. The trap crop can be destroyed after the cobs have been harvested.

Futher Reading

1. Kenis, M., Benelli, G., Biondi, A., Calatayud, P.-A., Day, R., Desneux, N., Harrison, R.D. et al. In press. Invasiveness, biology, ecology, and management of the fall armyworm, *Spodoptera frugiperda*. *Entomologia Generalis*. Available from https://doi.org/10.1127/entomologia/2022/1659

2. Harrison, R., Banda, J., Chipabika, G., Chisonga, C., Katema, C., Mabote Ndalamei, D., Nyirenda, S. & Tembo, H. 2022. Low Impact of Fall Armyworm (*Spodoptera frugiperda Smith*) (Lepidoptera: Noctuidae) Across Smallholder Fields in Malawi and Zambia. *Journal of economic entomology*, 115(6): 1783–1789.

3. Niassy, S., Agbodzavu, M.K., Kimathi, E., Mutune, B., Abdel-Rahman, E.F.M., Salifu, D., Hailu, G. et al. 2021. Bioecology of fall armyworm Spodoptera frugiperda (J. E. Smith), its management and potential patterns of seasonal spread in Africa. *PloS one*, 16(6): e0249042.

4. Hruska, A.J. 2019. Fall armyworm (*Spodoptera frugiperda*) management by smallholders. *CAB Reviews Perspectives in Agriculture Veterinary Science Nutrition and Natural Resources*, 14(043). https://doi.org/10.1079/pavsnnr201914043.

5. Harrison, R.D., Thierfelder, C., Baudron, F., Chinwada, P., Midega, C., Schaffner, U. & van den Berg, J. 2019. Agro-ecological options for fall armyworm (*Spodoptera frugiperda* JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. *Journal of environmental management*, 243: 318–330.

6. Hailu, G., Niassy, S., Zeyaur, K.R., Ochatum, N. & Subramanian, S. 2018. Maize–legume intercropping and push–pull for management of Fall Armyworm, stemborers, and Striga in Uganda. *Agronomy Journal*, 10: 2513:2522.

7. Midega, C.A.O., Pittchar, J.O., Pickett, J.A., Hailu, G.W. & Khan, Z.R. 2018. A climate-adapted push-pull system effectively controls fall armyworm, *Spodoptera frugiperda* (J E Smith), in maize in East Africa. *Crop protection*, 105: 10–15.

8. Jepson, P.C., Murray, K., Bach, O., Bonilla, M.A. & Neumeister, L. 2020. Selection of pesticides to reduce human and environmental health risks: a global guideline and minimum pesticides list. *The Lancet. Planetary health,* 4(2): e56–e63.

CIFOR-ICRAF harnesses the power of trees, forests, and agroforestry landscapes to address the most pressing global challenges of our time – biodiversity loss, climate change, food security, livelihoods and inequity.

cifor-icraf.org

Production: CIFOR-ICRAF Communications, Outreach and Engagement Team